DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Seismic

Using a Probabilistic Damage Control Approach to Design Bridges

PDCA helps assess post-earthquake performance and offers broader design options

JANUARY 2015

Project Title:
Probabilistic Damage Control Approach for Seismic Design of Bridges

Task Number: 2280

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Product Category: New technical standards and specifications

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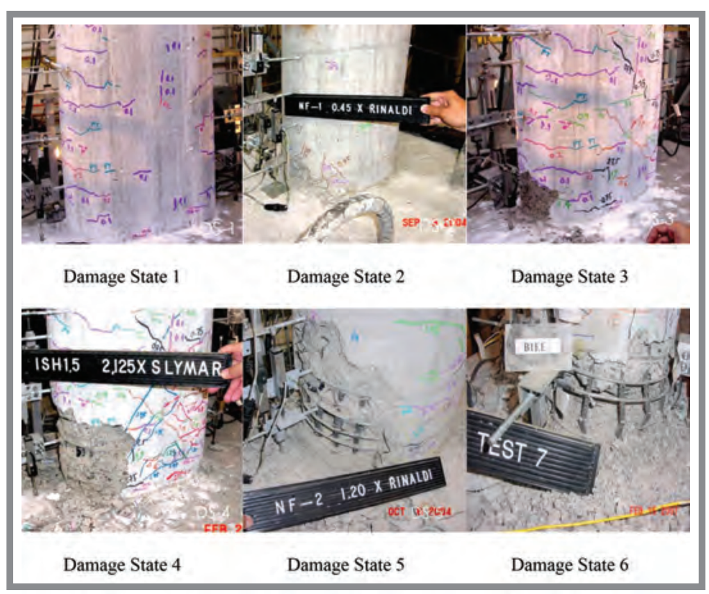
WHAT WAS THE NEED?

Earthquake engineering is transitioning away from using deterministic design criteria, which considers the largest magnitude earthquake at the nearest fault to the site to assess the potential level of damage. A relatively new design concept based on probabilistic seismic analysis incorporates the uncertainties in seismic demand and structural response to better control bridge performance. The Probabilistic Damage Control Approach (PDCA) evaluates how a structure is likely to perform under a given seismic hazard. PDCA incorporates the extent of column lateral plastic deformation at different probable earthquake levels and scenarios based on experimental results.

WHAT WAS OUR GOAL?

The goal was to develop a probabilistic damage control approach for the seismic design of bridge columns.



Possible apparent damage states of bridge columns

WHAT DID WE DO?

Caltrans, in partnership with the University of Nevada, Reno Department of Civil and Environmental Engineering, developed a probabilistic approach by incorporating the movement of the bridge as defined by the level of damage (damage index). The researchers subjected 22 bridge column models to seismic loads for over 140 use cases and correlated the bridge movement to visible damage states. They included a range of variables to capture nearly all possible bridge column designs, soil types, and earthquake intensities. Each column was analyzed under 25 near-field and far-field ground motions. The researchers also statistically analyzed the demand damage index to develop a load model and to determine the reliability index for each damage state.

WHAT WAS THE OUTCOME?

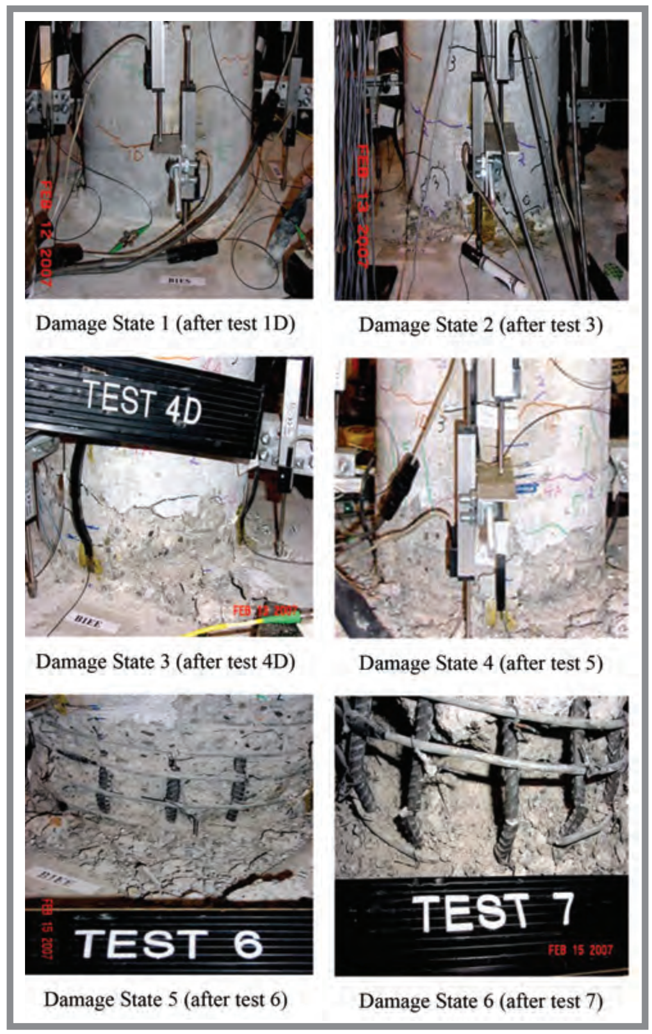
The results showed that the proposed method could be effectively used for designing new bridges as well as seismically assessing existing bridges. The researchers developed charts and equations for designing bridge columns and four illustrative examples to facilitate applying PDCA. Future research would expand the study to include old bridge columns that need to be evaluated. The new phase will help Caltrans engineers explore retrofit strategies using a probabilistic approach specific to the bridge rather than a deterministic “all or nothing” approach, which can be unnecessary and costly.

WHAT IS THE BENEFIT?

Under the current practice, standard bridges are designed mainly based on the seismicity of the site. Other factors, such as the average daily traffic, consequence of a temporary bridge closure, and post-earthquake repair costs, do not enter the design. The PDCA method allows for flexibility in design to account for economy, safety, and other concerns. PDCA also helps maintenance engineers make faster and better assessments of earthquake damages when timing is crucial in deciding whether to open a bridge or halt traffic.

LEARN MORE

To view the complete report:
http://wolfweb.unr.edu/homepage/saiidi/caltrans/Probablistic/PDFs/CCEER-14-02CompleteAug29-2014.pdf



Damage State 1 (after test 1D) Damage State 2 (after test 3)
Damage State 3 (after test 4D) Damage State 4 (after test 5)
Damage State 5 (after test 6) Damage State 6 (after test 7)

Damage states for bent 1 east column plastic hinge